SOME NEW DATA ON THE ORDOVICIAN LAND PLANTS FROM POLAND (3).

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In 1959 appeared in the *Acta Palaeontologica Polonica* (Vol. IV. No. 1. Warszawa, 1959) the paper of P. GREGUSS and R. KOZLOWSKY „Discovery of Ordovician Land Plants", a preliminary report on the primitive Ordovician land plants from Poland. In his second paper „Die Entdeckung von Urkormophyten aus dem Ordovizium (2) (*Acta Biologica,* Szeged, Tom. VII., Fasc. 1—2. 1961) P. GREGUSS has dealt more fully with the problem and from the plant rests described *Musciphyton ramosum* and *Hepaticaephyton simplex* as new species. In the Appendix of this paper the author stresses that some workers call into doubt the Ordovician origin of these plant rests and even their being primitive land plants at all, considering them rather as root particles of recent higher Spermatophytes *(Carex),* thus rating the whole find not of Ordovician but of subrecent origin. The author already in that paper — to justify his original view — compares the cross section structure of the thin roots of some *Carex* species with the cross sections of these plant rests, coming to the conclusion that there is no similarity whatsoever between the two kinds of structures and that these rests accordingly can not be root particles of recent plants. The author admits, already in this paper, that there is an external resemblence apparently supported by the drawings of the *Carex* roots examined by BERTSCH and MATJUSCHENKO, in the internal structures, howewer, there is a definite difference. Therefore the author does not think it likely that the Ordovician finds from Poland should be recent *Carex* root rests.

These contrary opinions anyway gave the author food for thought and aroused some suspicion with him, whether these plant rests prepared by Prof. KOZLOWSKY from Ordovician material are with absolute certainty of Ordovician origin, whether they did not get into it subsequently and if so, whether they are actually root rests of higher plants living at present and particularly of *Carex.*

Since the author up to now described only two of the plant rests obtained from Prof. KOZLOWSKY, though there are some more whose exact origine and proper place is in no way decided as yet, he upon mature consideration resolved to make known also these further rests, abstaining, however, from giving them new names. He merely intends to demonstrate to the world of science what plant rests were still there in that rock, originating, as stated, from the Ordovician. He will describe them in the condition as received from Prof. KOZLOWSKY, aligning — mainly in original unretouched photographs — the arguments that in his opinion seem to prove that these particles must have been derived from very primitive plants, mainly of the character of *Bryophyta.* There is none among the plant rests to be described whose derivation from higher *Spermatophytes* and the so called root origin could be definitely stated. On the evidence of external and internal morphological characters the author is still inclined to think that these plant particles, irrespective now of whether they originate from the Ordovicium or from a nore recent epoch, were rather quite primitive organisms than root rests of recent *Spermatophytes.* But even this standpoint is not maintained by the author with absolute definiteness. Probably some of the workers will support with objective arguments the correctness or incorrectness of one assumption or the other. The author has only some doubts raised by the geological period and the almost unimpaired persistence, much less as to the „root" origin.

Both in the 1. and 2. paper the author has briefly reviewed the conditions in which these plant rests came to light and were scientifically analysed. Photo No. 1. refers to the piece of rock, from which the plant rests to be described were prepared by Prof. KOZLOWSKY and handed over to the author for examination. Prof. KOZLOWSKY reports upon the conditions in which he obtained the plant rests as follows:

Phot. No. 1.

„For the purpose of etching from Ordovician calcareous rocks graptolites and other animals with chitinous skeleton the present writer has, for many years past, used the hydrochloric and acetic acid treatment. Recently, during this work, ha has discovered plant remains of particular interest.

The rocks which have yielded these organisms are erratic boulders carried to Poland from Scandinavia and the Baltic region by Pleistocene glaciers. Besides pulverized or minute fragments of calcareous animal skeletons they practically always contain numerous remains of chitinous skeletons, such as *Graptolithina, Annelida* (jaws) and *Hydroida.* Occasionally they also yield plant remains. The majority of these are referable to *Phycomycetes* and *Algae.* They occur in association with typically marine fauna and, most likely, were themselves marine organisms. Sporadically, howewer, among these aquatic plants remains are noted of other, higher organisations and probably of continental origin. These specimens have attracted the writer's attention as evidence of particular interest."

„The plants, for which GREGUSS has introduced the new generic name of *Musciphyton* gen. nov., were extracted from a boulder (No. o. 225), 1,65 kg in weight, collected near Zakroczym, in the valley of the Vistula. It is a compact palitic limestone, lithologically similar to the lithographic limestone of the Jurassic. This rock, familiar long since to geologists who study the erratic boulders of the North of Europe is by German writers referred to as „Ostseekalk". The grapholite *Orthograptus gracilis* (ROEMER) is its most common index fossil. Its age most probably corresponds to that of the „Saunja" (F 1 a) horizon, that is to the middle part of the Estonian Ordovician.

Boulder No. o 241, one kg. in weight, which has yielded plants called by GREGUSS *Hepaticaephyton,* was also collected near Zakroczym. It is a limestone with granular texture, almost entirely made up of calcareous fragments of indeterminate *Brachiopoda* and tests of *Echinodermata.* Juvenile gastropod shells and less frequent conodont denticles are encountered among these fragments."

„Chitinous remains are not common, being mainly those of *Scolecodonta* and *Chitinozoa; Phycomycetes* are abundant. The age of this boulder cannot be exactly determined on the animal remains it contains. *Scolecodonta* and *Chitinozoa* are common forms in Middle and Upper Ordovician boulders. Closer investigation of these remains may in the future lead to a more exact dating of this boulder. For the present, however, it is established as Ordovician."

On the evidence of these data the present author proposes to briefly describe some plant rests considered by him — conditionally — to be of rather quite simple, primitive, moss origin, not root particles. Since, however, this hypothesis is no certitude, he abstains from giving these forms specific or generic names and merely for discernment marks them with serial numbers, indicating at the same time which of *Musciphyta* and *Hepaticaephyta* they are most suggestive of. Further examination will have to decide on which side the truth is.

Datailed description of the plant rests:

No. 1
(Musciphyton?)
Plates I. and VI.

Plant height including twists is 2,2 mm, but when imagining the plant straightened out it must have been 3–3,5 mm high (1). The cone-shaped lower part was surely in the soil; this inference may be drawn from the fact, that from this part of the plant several, comparatively short root-hairs originated (Fig. 1., 2., 3.). The width (r) of the intact root-hairs is 10–11 μ, the length 100–200 μ. Tiny mineral substances adhered to the surface of the vegetative cone. Roothairs originated also from the upper part of the cone-shaped apex, from the region of the so called root-neck. The root-hairs have neither transversal walls, nor thickenings, but dentate thickenings are seen in some of them. Their walls are thin, of 2–2,5 μ.

The arrangement of the external epidermis cells near the root-apex is definitely discernible (a): The surface is covered with somewhat elongated, comparatively thick-walled short and long cells, arranged in most cases in longitudinal rows. In the root-neck region the length of the epidermal cells is 50–60 μ, the width 35–40 μ. Directly above the root-neck the epidermal cells are more or less of equal size. The cells above each other in the somewhat higher regions show differences in size (b), namely long and short cells are regularly alternating (b_1). For instance cells of the following size are arranged successively; 55–22–80–26–100–20 μ, so the alternating of the short and long cells is well observable.

20 epidermal cell-rows are arranged on the circumference of the tiny cylindrical stem so inference can be drawn on the thinness of the tiny stem. In the higher regions the epidermal cells are somewhat longer and there are much fewer short cells among them (c, c_1). The conductive bundle is definitely separating from the cortical cells at the end of the tiny stem. Simple pits forming a string are seen in the conductive elements.

Not even traces of leaf-primordia or sporangia were observable on the whole longitudinal surface of the stem, proving that the tiny plant represents a cylindrical, non-branching leafless primitive stem.

No. 2.
(Musciphyton ?)
Plates II. and VII.

The height of this plant was merely 1.5 mm (Fig. 1., 2.). Its cylindrical structure was clearly visible from outside. From the basis of the somewhat thickened lower part a short lateral shoot originated, of which the stump remained only. The diameter of the lower part is 0.6 mm, while that of the broken upper part 0.4 mm. The surface is covered with well visible thick walled epidermal cells. The shape of the epidermal cells on the lower part is more or less regularly hexagonal, while the cells arranged somewhat higher are square, irregularly quadrilateral or oblong (Fig. 2.). The cells in the upper regions are arranged

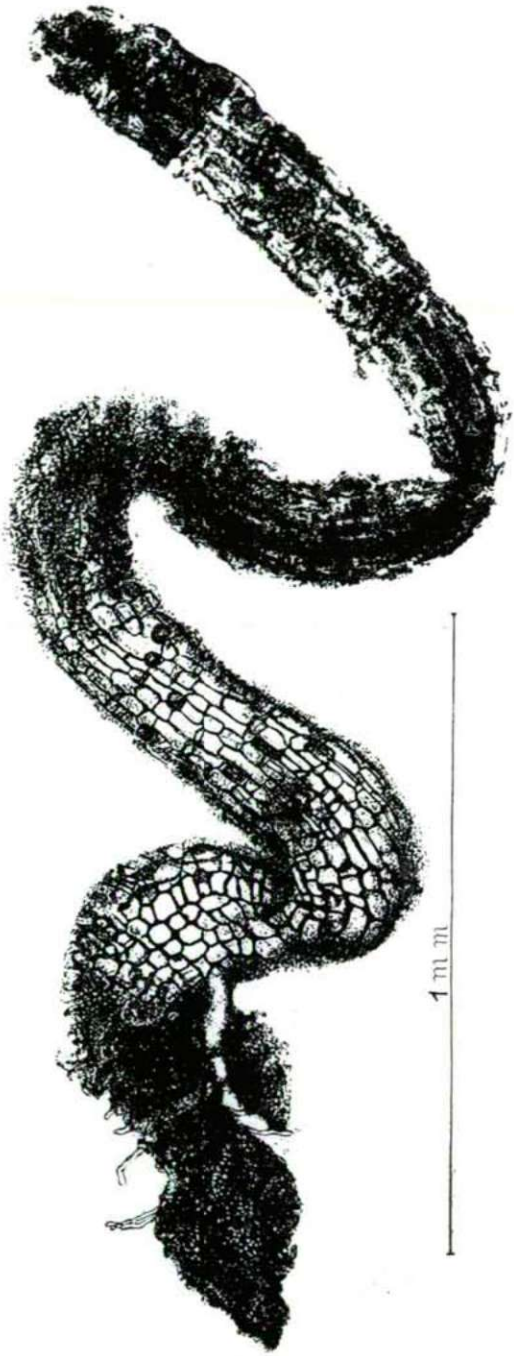

Plate I.
Plant No. 1. *Musciphyton?*

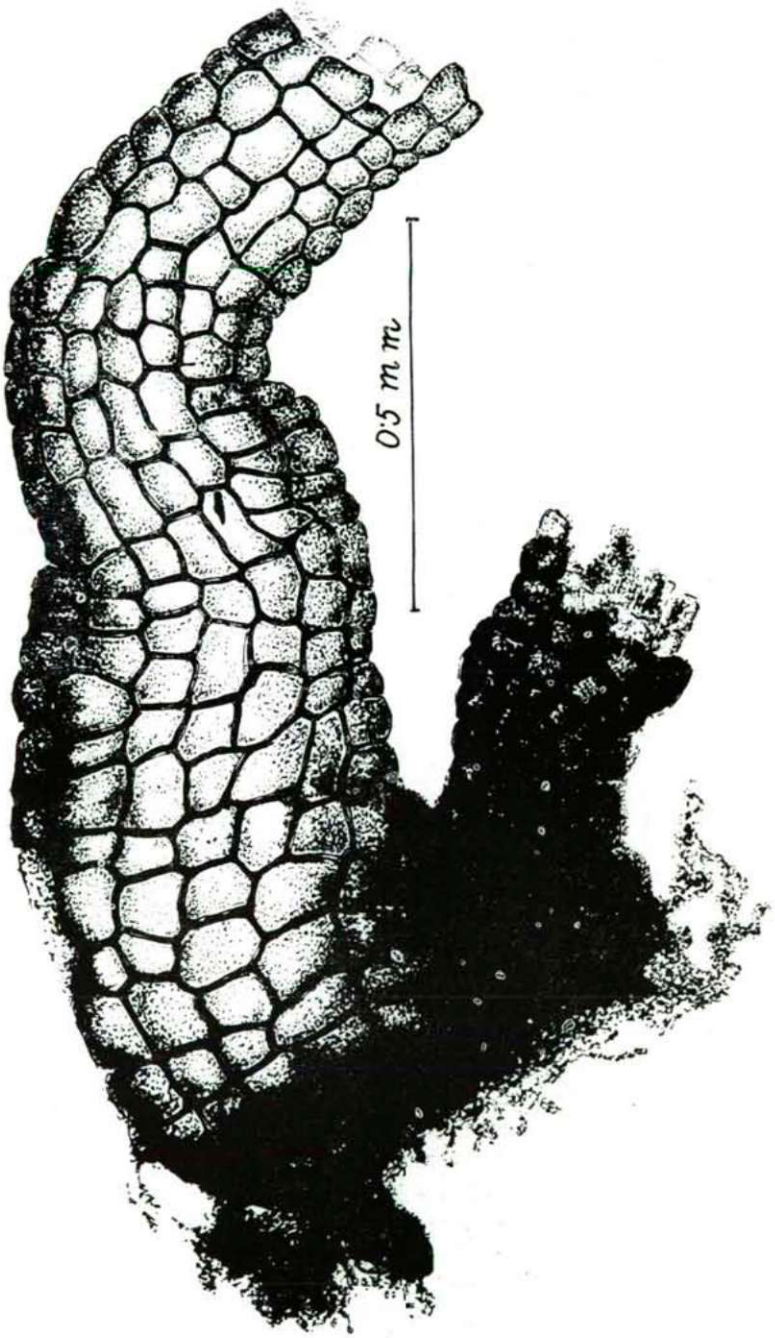

Plate II.
Plant No. 2. *Musciphyton?*

in definitely longitudinal rows.* Here and there the alternation of the elongated and short cells can be clearly established. In the thickened walls of the epidermal cells there is no particular thickening, also the inner wall towards the lumen appears to be entirely smooth.

From the lower part of the tiny plant no perceptible rhizoid-threads originated, at least such threads were not observed probably because of the minute soil particles sticking to the lower part of the tiny plant. The thinness of the tiny plant is illustrated by the fact that merely 12—14 epidermal cells are arranged on the circumference of the upper part. The height of the cells varied between 50—70 μ, while the width increased scarcely from the bottom to the top.

Since the cylindrical structure of this tiny plant was visible at the first glance, cross sections were prepared to examine the internal structure. We succeeded to prepare several cross-sections from the tiny piece of nearly 1 mm. The cross-section structure revealed that the external epidermis cell walls are significantly thicker than the internal walls. Below the comparatively high epidermal cell-layer followed a cortical cell-layer also with large cavities. The walls of these cells were very thin too. In the interior of the plant comparatively large cavities of the epidermal and cortical cells were conspicuous (3).

Next followed the central part, with 6 starshaped branchings. This structure showed in all probability the arrangement of the conductive elements (3). The minute longitudinal structure of the conductive elements could not be determined as we were compelled to sacrify the tiny plant for the sake of precise examination of the cross-section.

No. 3.
(Musciphyton ?)
Plates III. and VIII.

Plant size about 2.6 mm. The underground part lived in the soil probably as a rhizome, since the overground stem developed in a perpendicular direction, from the horizontal part. One end of the plant is substantially thicker than the other. The broader end is 280—300 μ, while the thinner part scarcely 100 μ thick. From the apex of the thicker end, the short part left of the conducting bundles can be seen. This bundle runs through the whole plant and in it the pearl-string simple-pitted thickening is definitely to be observed, as a rule in four longitudinal rows.** The conductive elements are covered with about 20 μ high and 70—80 μ long elongated parenchyma-cells; these are followed by the exterior cortical cells of 210—220 μ length and 40—50 μ height. The cortical cells are arranged usually in longitudinal rows.

Here and there tiny cones are seen on the side of the broadened stem (d_1, d_2); these are in all probability the places of the growing lateral shoots or vegetative cones almost invariably developing from the fitting together of four

* In the upper part the number of the rows is diminishing because one row follows as the continuation of two (see at the white arrow).

** Similar simple-pitted bead-string thickening was found also in the conductive elements of the Rhynia from the Devonian (Fig. 3.). The resemblance is rather striking.

Plate III.
Plant No. 3. *Musciphyton*?

cells almost suggesting that the lateral shoots would break out from there (d_1, d_2).

An essentially similar structure exists on the lateral branch arising from the horizontally running rhizome. Here too there are crest-like prominences, tiny cones. It is remarkable however that no roothairs or root-hair primordia were observed on this tiny plant.

No. 4.
(Musciphyton ?)
Plates IV. and IX.

Length of the tiny plant is precisely 2 mm, the height of the two lateral branches (band c) 0.9 mm. The first branching (b) is at a distance of 1800 μ from the one end, the second branching (c) at 1000 μ from the former, the knob-like broadened end at about 1200 μ from the latter. The lower part of the whole tiny plant had probably a rhizome-type position in the soil.

At the fore-part was probably the vegetative cone (a, a_1, a_2); the other end is likely to be broken off. This can be concluded from the shape of the cells and from the ending of the rhizome (d, d_1, d_2). Several root-hairs originate from the horizontally running rhizome-like part; their length may have been 60—100 or even 400 μ. Their walls are thin, on some of them the dentate thickening (R, R_1, R_2) is visible toward the cell-lumen. This structure is definitely suggestive of or corresponding to the dentate thickenings of the rhizoids of liverworts. Thus in this respect the liverwort character is beyond doubt.

The vegetative cone (?). On the fore-part of the tiny plant the broadly extending and widening vegetative cone (?) is clearly to be seen (1a, $2a_1$, $3a_2$); its thickness if of 650 μ. The surface is covered with oblong cells of different size; most of these are 100—110 μ long and 50—60 μ broad, others are larger or smaller. In the middle of the vegetative cone (?) toward a twin-cut leading-cell (?) an incision seems to appear: the vegetative cone (?) at the end of the stem is separated in two nearly equal parts. It is possible, however, that the surface cell was torn out from here and therefore a gap remained. A little further root-hairs originate from different parts of the tapering rhizome (2, 3). On some of the root-hairs it is clearly seen that they are in reality the bulges of an epidermal cell, while in others the basis protrudes as a pillow from the surface of the epidermis, tapering and turning to a real root-hair only after a one cell height.

From the basis of the branch particle with the vegetative cone ($2a_1$) root-hairs originated, but in the upper parts (b_1, b_2) no originating of root-hairs could be observed. The stem surface is covered here with somewhat elongated, oblong cells (b_1, b_2) in the direction of the axis. The length of the cells ranges between 50—100 μ, the width between 40—45 μ. The end of the tiny stem is broken off, the shape and arrangement of the cells near the breaking-place clearly show that the tiny stem was cylindrical (b_2). Its circumference is covered-with thick-walled epidermal cells. One or two layers of thin-walled cortical cells follow and conductive elements are running in the interior. A pearl-like thickening was observed in the conductive elements, under considerable enlargement.

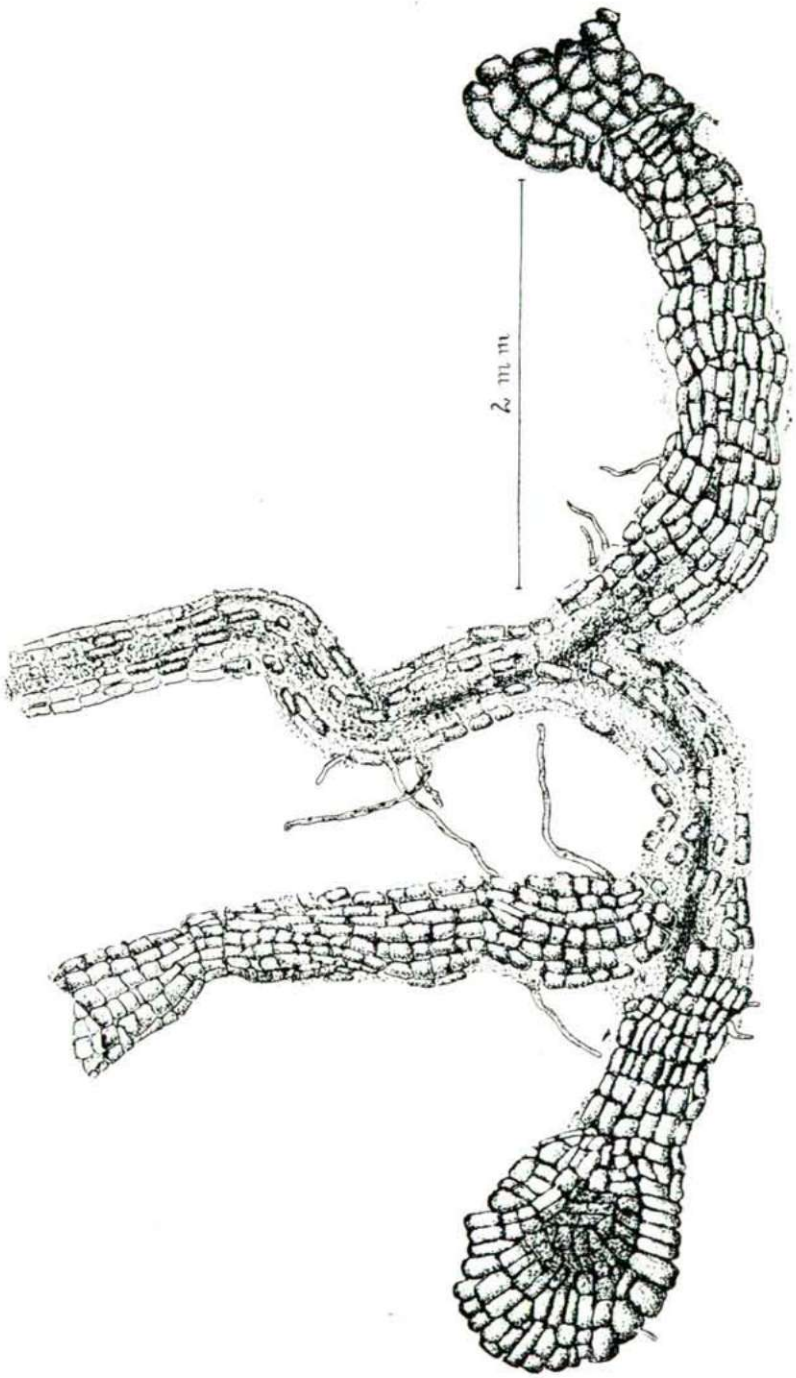

Plate IV.
Plant No. 4. *Musciphyton*?

The second lateral branch (c^1, c^2) is 2 mm. The surface toward the axis is covered with corticalcells, extended in the direction of the axis. The length of the cortical-cells is different, they are at some places 270—300 μ long and 35—40 μ wide. Their outer walls are considerably thicker than those of the underlying cortical-cells. Such arrangement of the cortical-cells exists also in other *Musciphyta* (see Plate I.). Some root-hairs are originating from the basis of this tiny stem (c_1); this allows of the conclusion, that the plant might have been to that depth in the soil.

The other end of the stem (d, d_1, d_2) is essentially similar to the structure of the part with the vegetative cone (a, a_1, a_2). From the basis of the latter also shorter or longer root-hairs originate. The surface cells are here somewhat longer (150 μ), their. width measures 65—70 μ. The walls are comparatively thick.

A *Hystrichosphaera* (H, H^1) was sticking to the root-hairs.

Were it not for the vegetative cone-like ending, the rhizoid with the dentate thickening and the adhering *Hystrichosphaera,* the structure would be suggestive of some *Carex* root. In the author's opinion, however, the latter assumption is unlikely.

No. 5.
(Hepaticaephyton ?)
Plates V., X. and XI.

The maximal length of the tiny plant is 1.6 mm. Its flatly prostrated thallus clung to the soil in all probability with a short root part; one branch of the dichotomous branching reached a length of 1.5 mm, the other 0.9 mm. Another dichotomous lateral branch primordium was on the longer branch at a distance of 1.1 mm, while on the ahorter side the dichotomous branching occurred already at a distance of 300 μ (Fig. 1.). The ends of all tiny branches seemed to be broken off, i.e. these are no natural endings. A natural ending could be only supposed at the end of the lower branch (Plate X. Fig. 1.). The tiny plant is definitely flattened, the width of the flattened stems is 200—210 μ, diminishing in some places to 110—120 μ, probably as a consequence of the flat stem turning somewhat upwards with its edge.

A vigorous longitudinal crest runs along the middle of the flat body; adjacently here and there 2—3 much lower crests are found. The crest is not everywhere continuous, in some places it is broken and runs sinuously (Fig. 2 to the right). From the lateral side of the flat body at a distance of 150—200 μ $\pm$ triangle shaped lobes are branching off; from their endings often enough 200—300 μ long flat and multicellular hairs (2a) are ramifying. The distinct rhizoid part marked with r on the drawing appeared but at few places as soil-particles clung to it. The part corresponding to the cauloid is about 150 μ long, somewhat cylindrical, with two cylindrical shaped root-hairs or rhizoids originating from the base. These two root-hairs differ clearly as against the hairs branching from the lateral side of the plant.

The assimilating hairs (?) are generally found in the continuation of the thallus-lobes at a more or less regular distance from each other (Fig. 2.). These hairs are definitely flat and somewhat twisted around the axis (Plate XI.) Their surface is covered with very fine and tiny warts. The ends of the hair-struc-

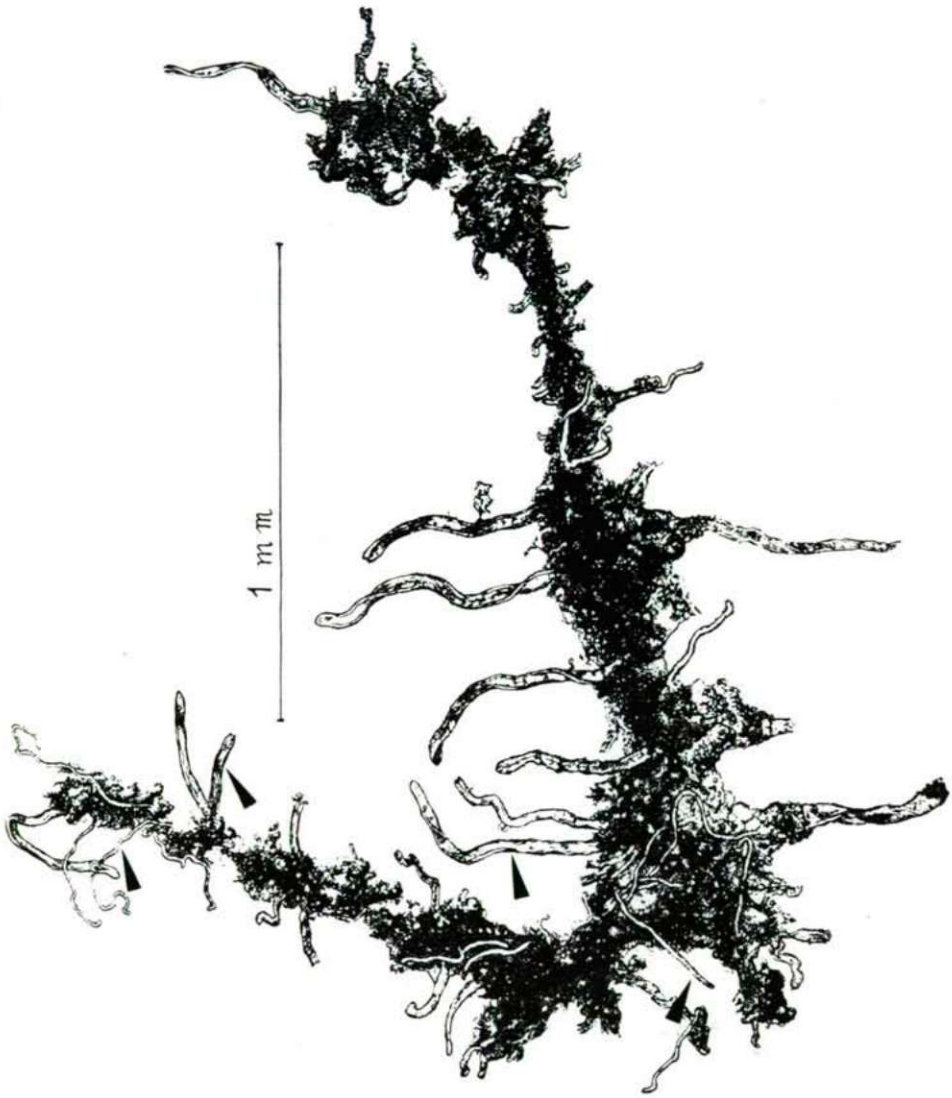

Plate V.
Plant No. 5. *Hepaticaephyton?*

tures are as a rule tapering (2 d). A separated short basal cell is found at the bottom of some hairs (b_1, c, d). There are unicellular and multicellular ones. Some of the multicellular have a structure comporable to the hairs branching from the thallus of the liverwort *Higrobliella laxifolia* (Plate XI. 2. a_1).

The whole structure of this tiny plant — strange though it may appear — outwardly reminds up to a certain degree of the *prothallium* structure of

Psilotum triquetrum, but on the whole surface there were no parts suggestive of *archegonia* or *antheridia*.

Whether this tiny plant belongs to the *gametophyton* or to the *sporophyton* generation could not be determined as it has neither reproductive organs nor *sporogonia*. If belonging to the *gametophyton* generation it is to be considered as a moss or perhaps as some *prothallium*, but if it was a *sporophyton*, it should be referred to as *Propsilophyton*.

On the whole the plagiotropic and flat body of our tiny plant differs entirely from the cylindrical stem of the above described *Musciphyta;* the plant is of the clearly dichotomously branching liverwort type *Hepaticaephyton (?)*.

No. 6.
(Hepaticaephyton ?)
Plate XII.

The tiny plant was photographed after having been prepared from the limestone by dissolution. Its total height in this condition was 8.5 mm. With careful handling we were able to separate two tiny plants from this group. Both have essentially the same structure as each has a rhizoid, a short non-branching cauloid and a dichotomously branching phylloid *thallus*-part. In this intact condition a cone-shaped tiny body (s) protruded from the entangled flat *thallus*-parts which after precise examinations proved to be probably a *sporogonium*, all the more since some spores adhered to it externally (s).

One of the tiny plants has 2–3 claw-like flattened extensions on the part fixing the plant to the soil (2a, $3a_1$). This claw-like structure is az a whole similar to the corresponding part of some liverwort adhering to the bottom. The non-branching cauloid part is about 1 mm long, its top is dichotomously branching; when the lateral branches thus produced ramify again, the branching is once more dichotomous (2). In the interior of the cauloid part the conductive bundle consisting of the elongated cells shows through the cortical cells. Here the surface cells are elongated but comparatively low oblongs 14–16 μ high and 110 μ long.

In the original condition of the plant one *sporogonium (?)* emerged out of the entangled stems as seen on the photo (Fig. 2, 4). During the further operation unfortunately the *sporogonium* itself broke but, as the photo shows, we succeeded by assembling the parts in reconstructing exatly its shape.

The bottom of the *sporogonium* at the end is 130–140 μ wide (Fig. 6.), this width grows successively, reaching in the middle 300–400 μ and at the widest part 600–700 μ. From this part on the tapering is more sudden and the upper end is scarcely 200 μ thick.

When carefully disentagling the tiny plant we succeded in observing three spores amidst the entangled threads sticked to each other next to the *sporogonium*. The spores were definitely three-edged consequently tetraedric. They were similar to the spores of some living liverworts (7 sp.).

Still our tiny plant in its whole construction with its dichotomous branching is most suggestive of the living liverworts, but it also resembles to the Devonian *Zosterophyllum;* it can not be identified, however, with the root system of any seedy plant.

Summary

Arguments in favour and against the Ordovician origin of the plant rests are summarized as follows.

Plant No. 1. (Plates I. and VI.) in its habit is actually suggestive of some *Carex* roots, the shape of the external epidermal cells being indeed also similar. In contradiction to this supposition, however, the epidermal cells in the root region are much shorter, square (a), while in the upper part oblong; root-hairs occur in a great number only in the thickened part while in the upper portion there are none. The roothairs are unicellular, with dentate thickening (see black arrow), such as do not occur in higher plants.

Plant No. 2. (Plates II. and VII.). The arrangement of the epidermal cells is similar to the epidermis structure of *Carex* roots, but the tiny stem is much thicker at the base than in the upper part. In the upper part the number of the peripheral cells is lower than in the lower part, thus the tiny stem is upwards tapering (see at white arrow). From the base a lateral shoot originates that is broken off. The cross section also shows a picture different from the interior structure of *Carex* species. The conductive elements are arranged in the centre in a star shape (2a).

Plant No. 3. (Plates III. and VIII.). On the surface the epidermal cells are partly similar to those in *Carex* species, but there are small warts that can not be considered as root-hair primordia (d, d_2). In the interior the conductive elements have simple pitted thickenings as in the *Rhynia* from the Devonian (Fig. 4.).

Plant No. 4. Plates IV. and IX. The habit reminds of *Carex* roots, but in contradiction to any such hypothesis the flatly extending „vegetative cone" as an ending substantially differs from the vegetative cone of higher plants (a_2). From the part in the earth rhizoids originated with explicit dentate thickenings (r, r), such as do not occur in higher plants. A *Hystrichosphaera* sticks to the plant (H).

Plant No. 5. (Plates V., X. and XI.). Cannot be compared with any organ of a higher plant. It is most suggestive of some sort of liverwort. Besides the thin root hairs (2b) multicellular assimilating hairs (a_1) are frequent. These depart from a broad base, follow each other at almost regular distances and are explicitly flattening. They can in no way be compared with the root hairs of higher plants (Plate XI.)

Plant No. 6. Plate XII. Can not be compared with the root system of higher plants. The claw-shaped basis (a), in its continuance the short stem and the repeatedly and dichotomously branching *thallus* portion originating from the upper part of the stem is suggestive of some liverwort. The part among the *thallus* particles similar to a *sporogonium* (S) and the few spores found here (Sp) seem to support this hypothesis.

Plate XIII. The Ordovician origin is also supported by some *Hystrichosphaeridium*-like unicellular organisms prepared by the author from the piece of boulder received from Prof. KOZLOWSKY. Fig. 1. represents a *Hystrichosphaeridium* of EISENACH from the Silurian, while Fig. 1 a. refers to our boulder. Similarly the Figs. 2., 3., 4. and 5. are from the Silurian paper of EISENACH while 2.a, 3.a, 4.a and 5.a from our rock. Figs. 6—12 all refer to

our boulder; they could not be determined as yet. With one exception (12) they all have an echinulate surface, so they belong to all probability to the same or to similar groups. Thus their origin and systematical place is: *incertae sedis.*

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Summing up arguments and counter-arguments the author still refrains to take a definite stand on the problem, whether these tiny plants actually originate from the Devonian. Several arguments support the view that these tiny plants or plant portions to some extent definitely differ from recent plants; on the other hand they posses certain properties that suggest some considerations before pronouncing a definite judgment. Further examinations and findings will finally decide the question whether these plants or plant parts were originally included in the boulder that beyond doubt originates from the Ordovicium or subsequently found their way into the rock. The primitive structure of these plants presents by all means a difficult problem to the biologist.

For that very reason author asks for succour of all those, who in spite of the arguments mentioned by him above, regard these plantrests as root-rests of recent-plants (for instance KRÄUSEL, SCHMIDT, SOÓ etc.), to denominate precisely those recent-plants, with that they can them identify. Till now author had no succes in this, neither on the basis of the *Carex*-data of BERTSH and MATJUSCHENKO, nor according to his own research. If we assert something, we must also prove it. For the kind communication author thanks in advance.

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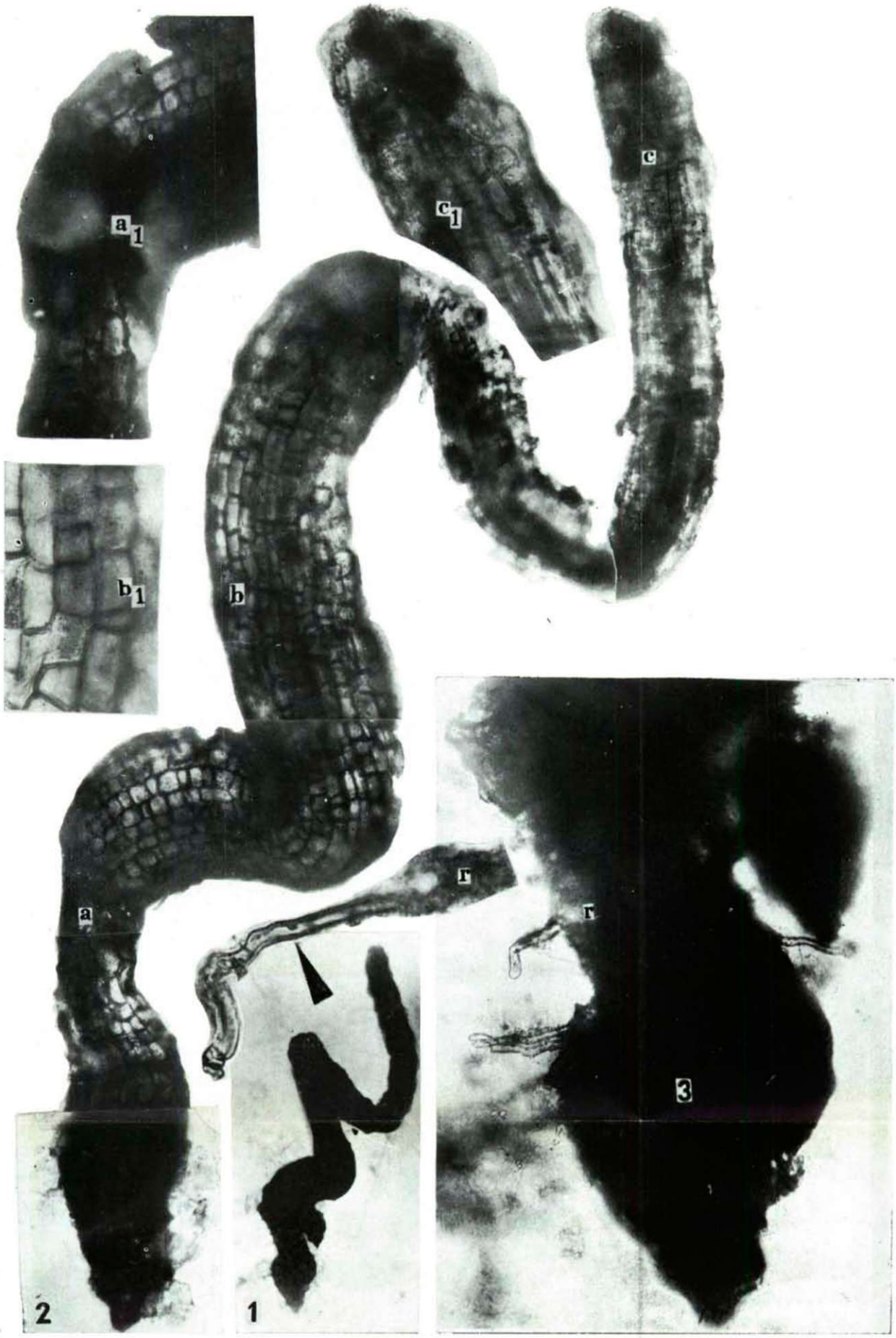


Phot. Greguss

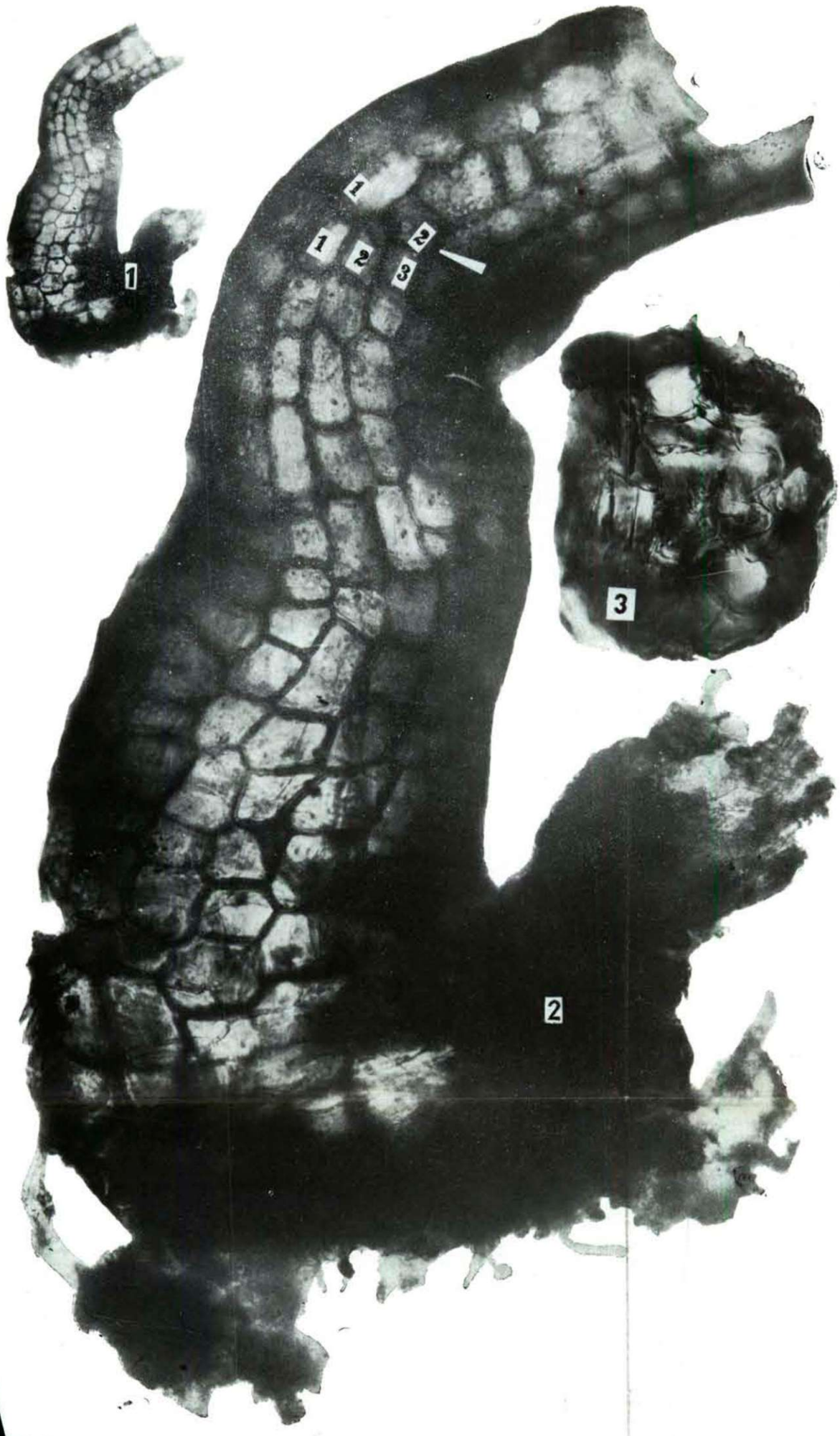
Plate VI.

Plant No. 1. *(Musciphyton?)*

Fig. 1.: The tiny plant in prepared condition. Roothairs only developed in the conic part (20× appr.)

Fig. 2.: The same. Epidermal cells on the surface are shorter at the base (a) then elongating (b); they are the longest at the endings (c) (60×). Detail from Fig. 2 (a_1, b_1, c_1) 100×).

Fig. 3.: At the broadened ending of the tiny plant roothairs or rhizoids (r). Besides, separately a root-hair or rhizoid with dentate thickening (100×). The root-hair separately (r) (300×).

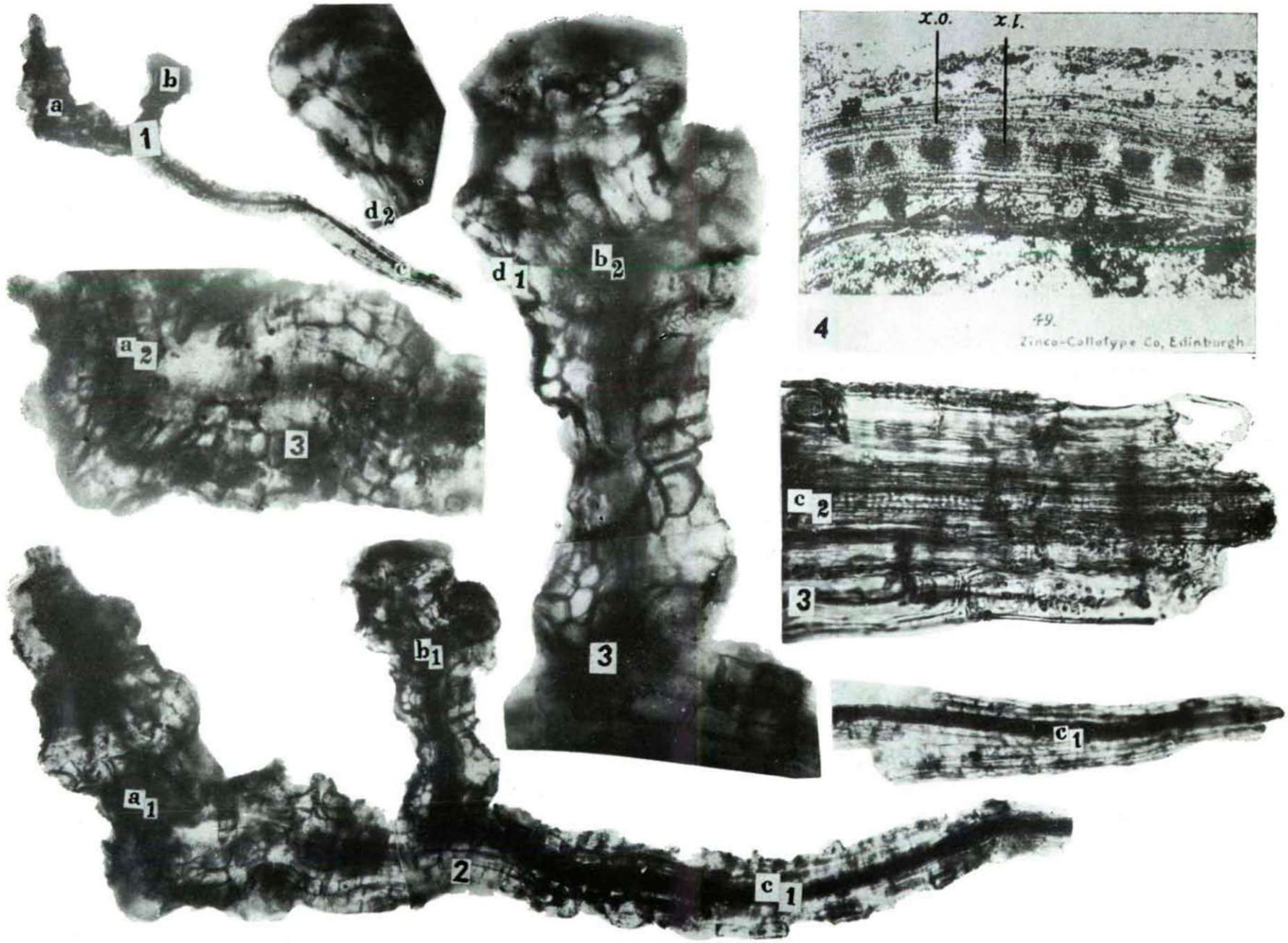


Phot. Greguss

Plate VII.

Plant No. 2. *(Musciphyton?)*

Fig. 1.: The tiny plant in prepared condition (40×). Original size 1,5 mm.
Fig. 2.: The same (120×).
Fig. 2a: Cross section structure of the tiny plant. The great epidermal and cortical cells are conspicuous. In the middle conductive elements arranged in star-shape (120×).



Phot. Greguss

Plate VIII.

Plant No. 3. *(Musciphyton?)*

Fig. 1. a., b., c.: The tiny plant in prepared condition (40×).

Fig. 2. a_1, b_1, c_1: The same, more enlarged. On the surface a number of knobs can be observed consisting each of 4—6 cells (a). On the surface of the tiny stem, crests and bud-shaped protuberances are seen (b_1). In the interior of the plant part a conductive bundle (c_1).

Fig. 3. a_2, b_2, c_2: On the surface of the plant the cells are oblong with bud-shaped protuberances on the surface (a_2). On the surface of the plant portion the cells are of varied shapes, forming thinner or broader crests or massing into little bud-shaped cones (d_1, d_2). To the apex of the stem in the conductive elements there are simple pits following each other as the beads of a string. Cortical cells are much longer here than in the lower part of the stem (c_2).

Fig. 4.: Detail of the Devonian *Rhynia* where in the conductive bundles the pearl string-shaped thickenings are the same as in Fig. c_2.

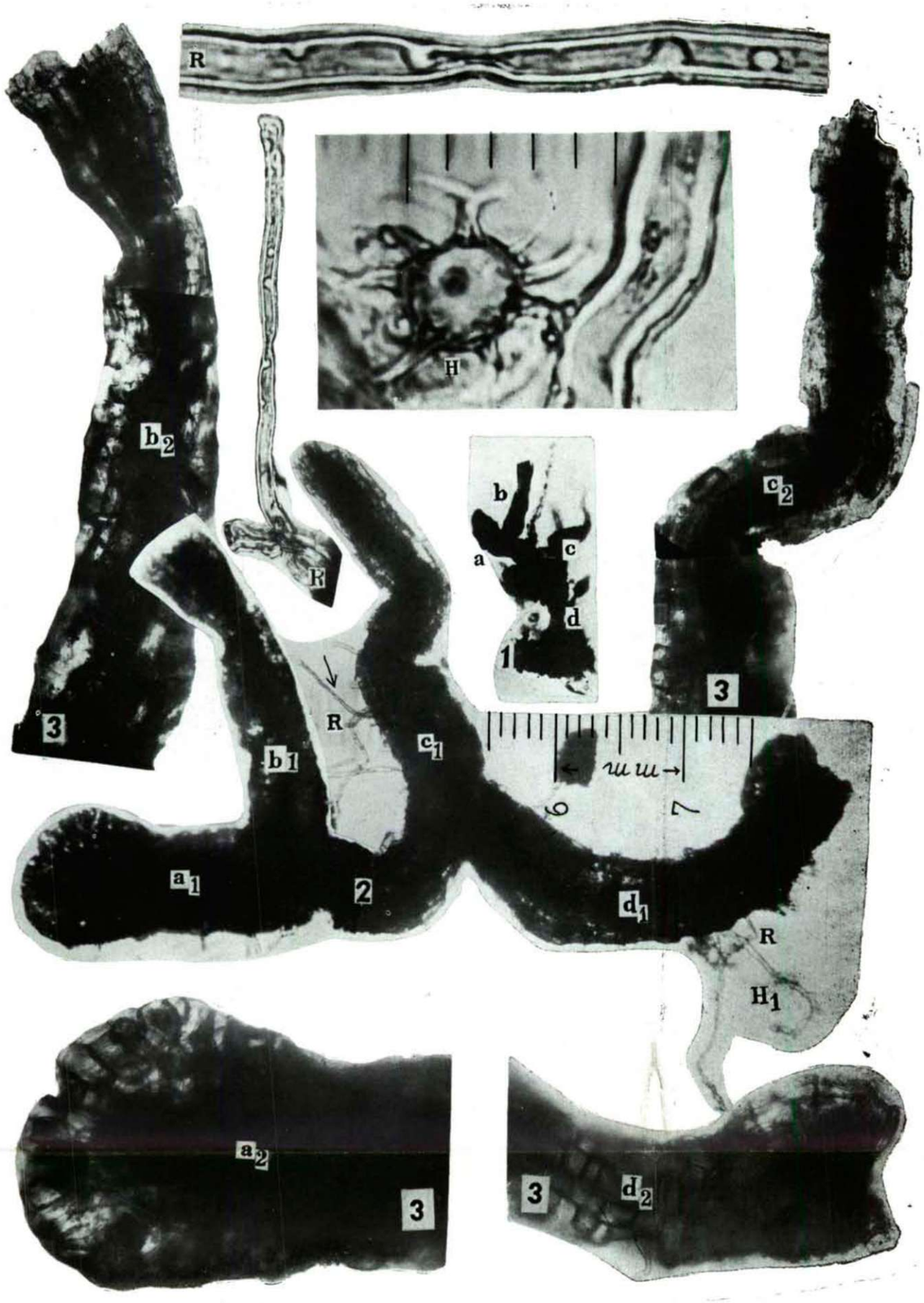


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Plate IX.

Plant No. 4. *(Musciphyton?)*

Fig. 1.: The tiny plant in half prepared condition. Rock particles still stick to its surface (40×). The several branching portions of the plant (a, b, c, d).

Fig. 2.: The same plant in fully prepared condition. At the apex a broadening vegetative cone (a_1). Protruding stem portions (b_1, c_1). From c_1 rhizoids with dentate thickenings originate (R). Between the two stem parts a single rhizoid with explicitly dentate thickening. Detail of rhizoid more enlarged (R_1). The other ending of the tiny plant (d_1). A *Hystrichosphaera* sticking to the rhizoid (H_1). Single *Hystrichosphaera* next to the root hair (H).

Fig 3.: Some portions of the tiny plant. The ending of the stem rounded off (vegetative cone?) (a_2). Portion of the rising tiny stem (b_2, c_2). The other ending of the stem (d_2).

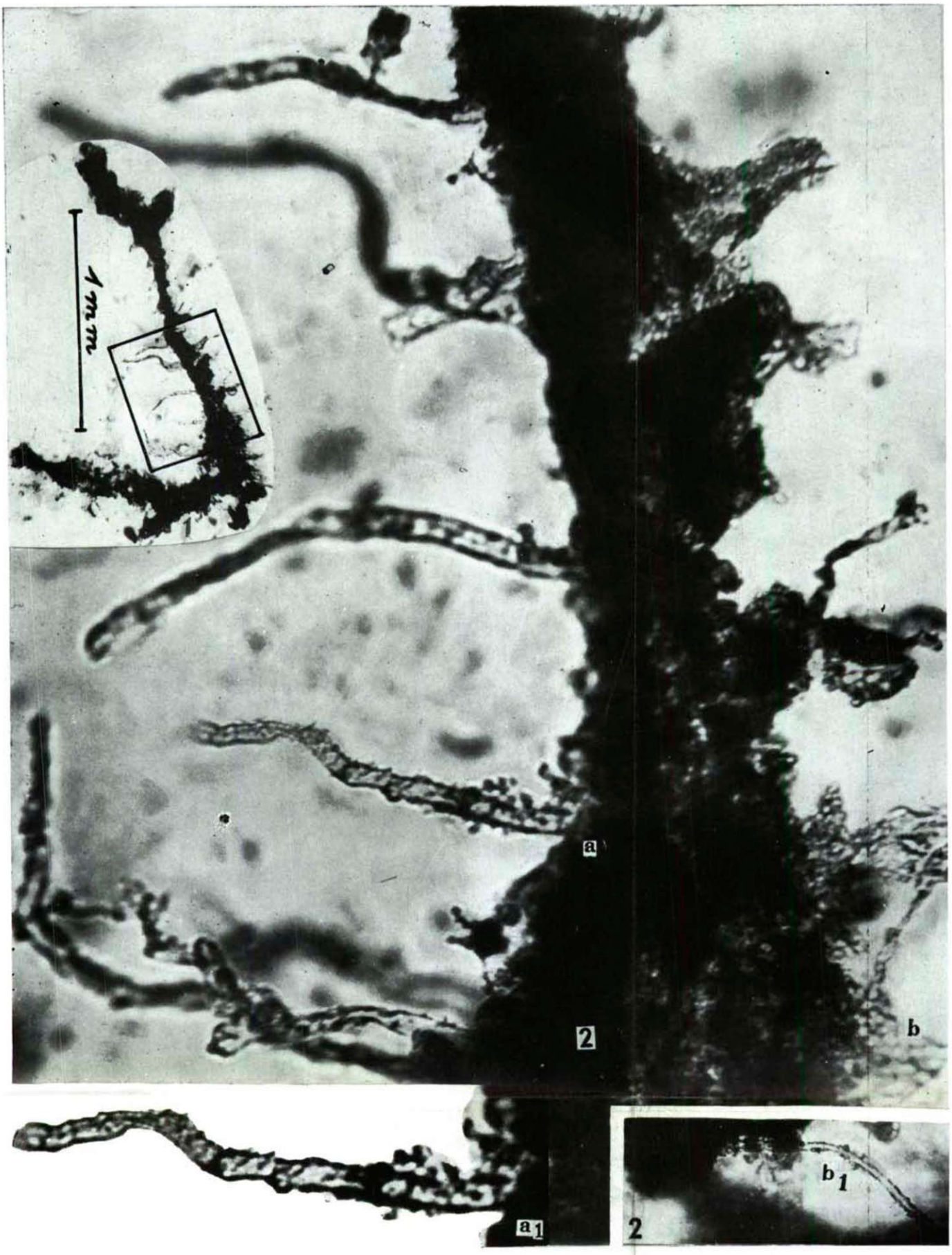

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Plate X.

Plant No. 5. *(Hepaticaephyton?)*

Fig. 1.: The tiny plant in prepared condition. Size: 1,5 mm. The encircled detail is shown in Fig. 2. (Magnification: 60×). From the *thallus* assimilating (?) hairs originate at equal distances. In a): multicellular non-branching hair. The same separately (a_1).

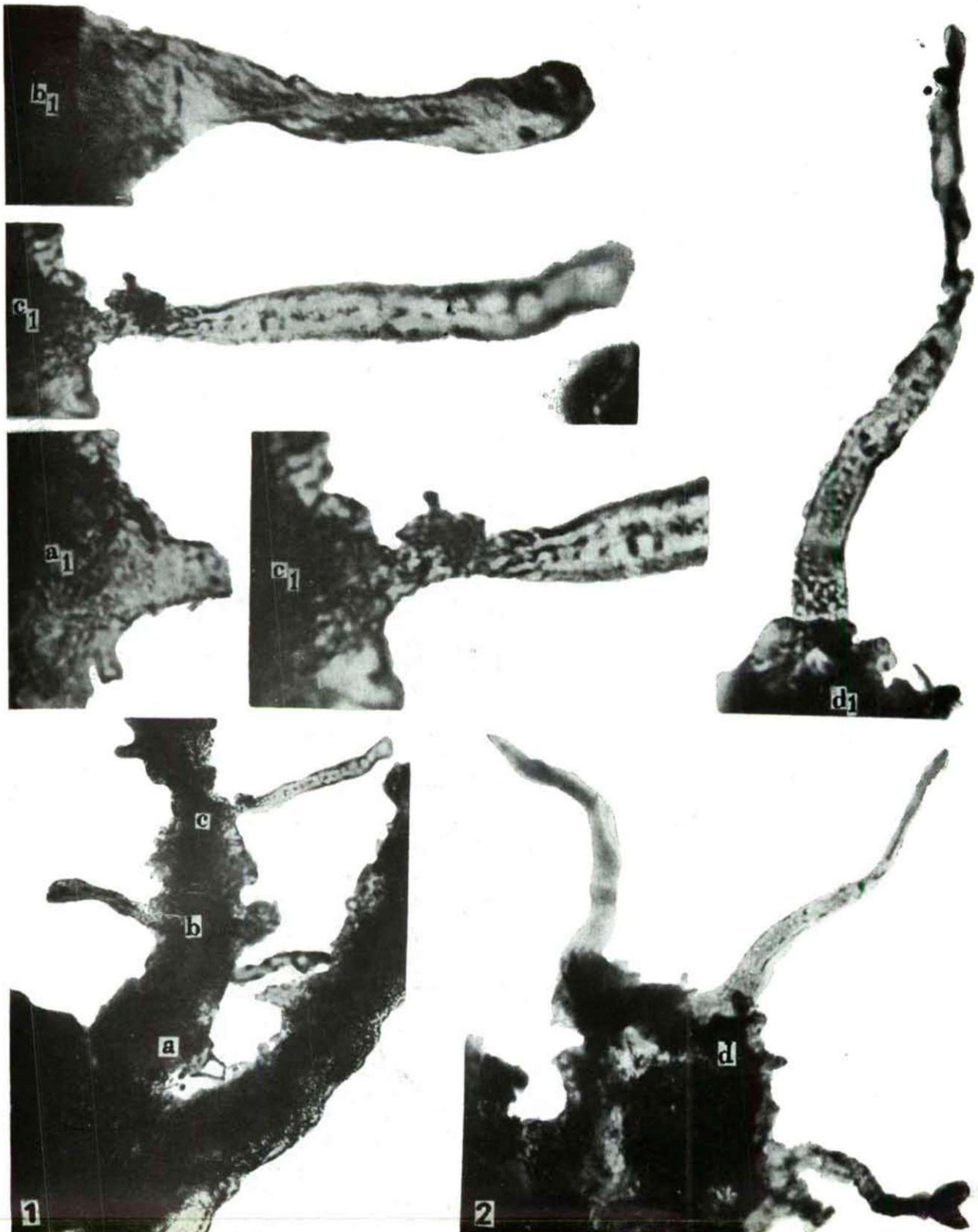

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Plate XI.

Plant No. 5. *(Hepaticaephyton?)*

Fig. 1.: Epidermal structures in a portion of the tiny plant No. 5 (a, b, c). The same epidermal structures more enlarged. The lower part of the structures is unicellular and broadening (a_1, b_1, c_1, d_1).

Fig. 2.: The flat ending of the *prothallium(??)* is curving in wards, on its surface there are long epidermal structures (d). A single hair structure originates from a conically protruding part, the lower portion is unicellular, the surface warty, and the surface of the hair structure also (d_1).

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Plate XII.

Plant No. 6. *(Hepaticaephyton?)*

Fig. 1.: The tiny plant in prepared condition. Dichotomous branching. Height 8,5 mm.
Fig. 2.: The same, more enlarged. The lower part showing claw-shaped broadening (a). Between the flat branches probably *sporogonium* (S).
Fig. 3.: The claw-shaped ending more enlarged (a_1).
Fig. 4.: Between the flat stems cylindrical half-broken *sporogonium(?)* (S).
Fig. 5.: The prepared and broken *sporogonium(?)*
Fig. 6.: The prepared *sporogonium* more enlarged.
Fig. 7.: Three spores prepared from among the tiny stems, not from the *sporogonium*.

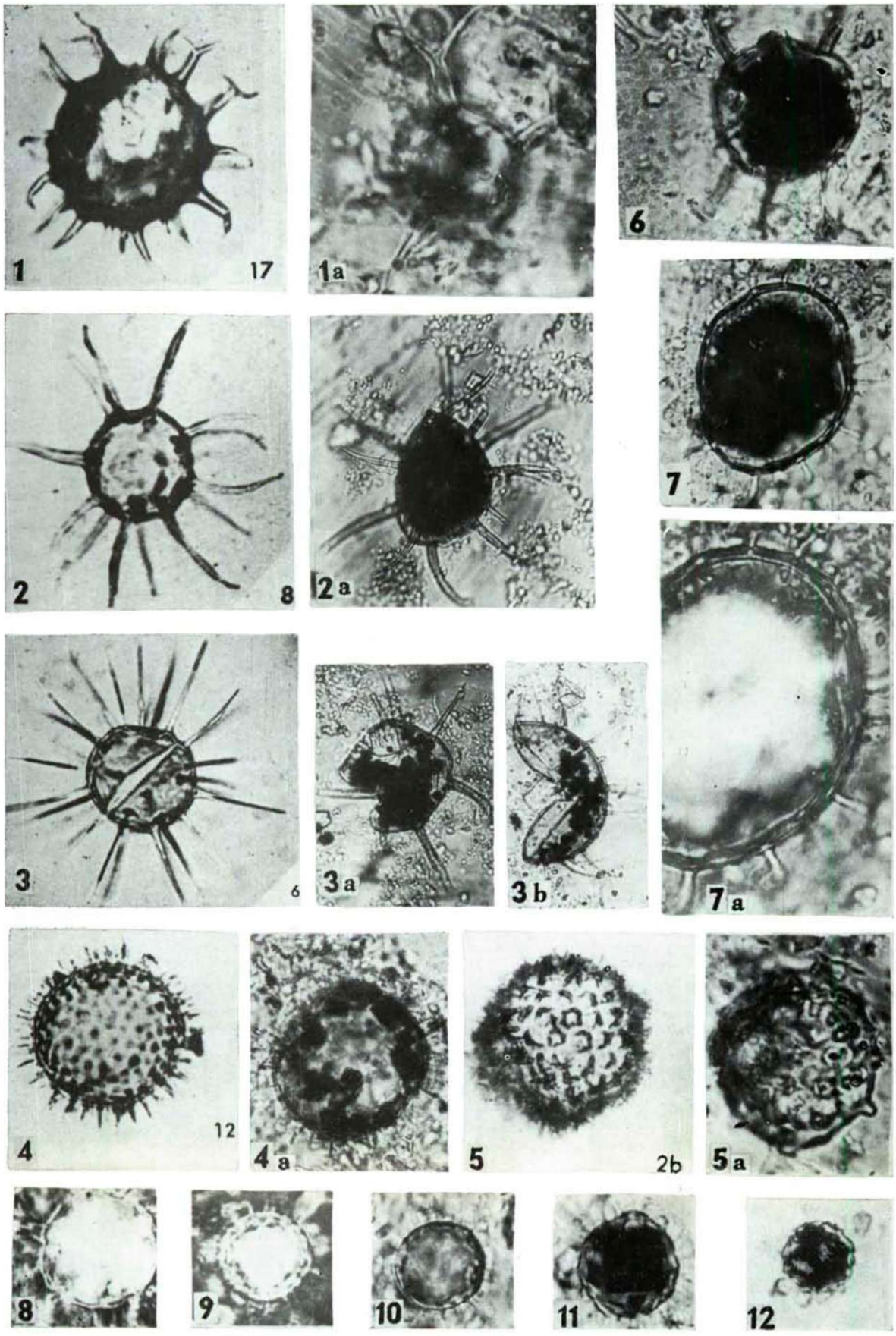

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Plate XIII.

Unicellular organisms from the boulder

Fig. 1.: *Hystrichosphaeridium*. From EISENACH's paper.
Fig. 1. a.: A form similar to No. 1. (from aur boulder).
Fig. 2.: *Hystrichosphaeridium*. From EISENACH's paper.
Fig. 2. a.: A form similar to No. 2. (from aur boulder).
Fig. 3.: *Hystrichosphaeridium*. From EISENACH's paper.
Figs. 3. a. and b.: Forms similar to No. 3. (from aur boulder).
Fig. 4.: *Hystrichosphaeridium*. From EISENACH's paper.
Fig. 4. a.: Form similar to No. 4. (from aur boulder).
Fig. 5.: From EISENACH's paper.
Fig. 5. a.: Form similar to No. 5. (from our boulder).
Fig. 6.: Form similar to No. 1. a., the thorn dichotomously branching, see ending of thorn broken off in the upper left corner.
Fig. 7.: *Incertae sedis* from our boulder.
Fig. 7. a.: Detail of No. 7 enlarged 2×.
Figs. 8—12: Structures of thorny surface, determination uncertain. All from our boulder.